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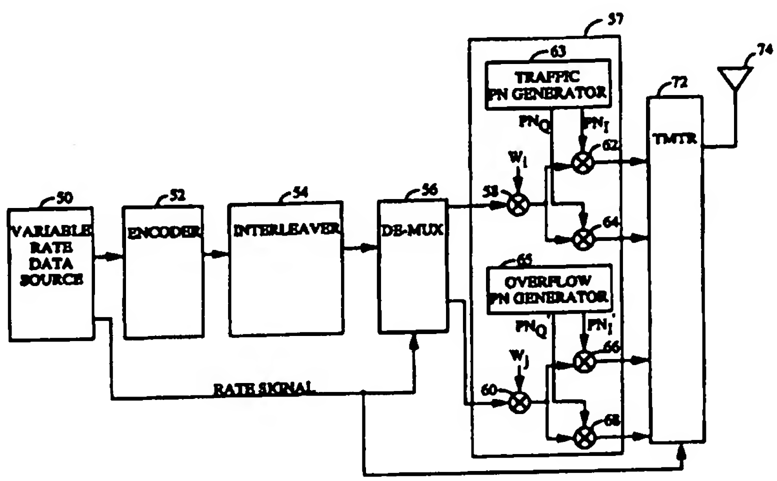

(57) Abstract

The present invention discloses a variable rate transmission system wherein a packet of variable rate data is modulated in accordance with a traffic channel sequence supplied by a traffic PN generator (63) if the capacity of said traffic channel is greater than or equal to said data rate of the packet. If the capacity of said traffic channel is less than said data rate, the packet of variable rate data is modulated in accordance with the traffic channel sequence supplied by the traffic PN generator (63) and in accordance with at least one overflow channel sequence supplied by an overflow channel generator (65). The present invention further discloses a receiving system for receiving variable rate data where a received packet of variable rate data is demodulated in accordance with a traffic channel sequence supplied by a traffic PN generator (104) if the capacity of said traffic channel is greater than or equal to a data rate of said packet. If the capacity of said traffic channel is less than said data rate of the packet of variable rate data, the received packet is demodulated in accordance with a traffic channel sequence supplied by a traffic PN generator (104) and in accordance with at least one overflow channel sequence supplied by an overflow channel generator (120).

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METHOD AND APPARATUS FOR PROVIDING VARIABLE RATE DATA IN A COMMUNICATIONS SYSTEM USING NON-ORTHOGONAL OVERFLOW CHANNELS

BACKGROUND OF THE INVENTION

I. Field of the Invention

The present invention relates to communications. More particularly, the present invention relates to a novel and improved communication system wherein a user transmits variable rate data on an allocated traffic channel, but when the user's variable transmission exceeds the capacity of the allocated traffic channel, the user is provided temporary use of an overflow channel to use with the allocated traffic channel in order to transmit the high rate data.

II. Description of the Related Art

The use of code division multiple access (CDMA) modulation techniques is one of several techniques for facilitating communications in which a large number of system users are present. Other multiple access communication system techniques, such as time division multiple access (TDMA), frequency division multiple access (FDMA) and AM modulation schemes such as amplitude companded single sideband (ACSSB) are known in the art. However the spread spectrum modulation technique of CDMA has significant advantages over these modulation techniques for multiple access communication systems. The use of CDMA techniques in a multiple access communication system are disclosed in U.S. Patent No. 4,901,307, entitled "SPREAD SPECTRUM MULTIPLE ACCESS COMMUNICATION SYSTEM USING SATELLITE OR TERRESTRIAL REPEATERS", assigned to the assignee of the present invention, of which the disclosure thereof is incorporated by reference. The use of CDMA techniques in a multiple access communication system is further disclosed in U.S. Patent No. 5,103,459, entitled "SYSTEM AND METHOD FOR GENERATING SIGNAL WAVEFORMS IN A CDMA CELLULAR TELEPHONE SYSTEM", assigned to the assignee of the present invention, of which the disclosure thereof is incorporated by reference.

The method and apparatus for the generation of a pseudorandom noise (PN) signal that is well suited for CDMA applications is disclosed in U.S. Patent No. 5,228,054 issued July 13, 1993, entitled "POWER-OF-TWO

LENGTH PSEUDO-NOISE SEQUENCE GENERATOR WITH FAST OFFSET ADJUSTMENT", assigned to the assignee of the present invention, of which the disclosure thereof is incorporated by reference.

CDMA by its inherent nature of being a wideband signal offers a form of frequency diversity by spreading the signal energy over a wide bandwidth. Therefore, frequency selective fading affects only a small part of the CDMA signal bandwidth. Space or path diversity is obtained by providing multiple signal paths through simultaneous links from a mobile user through two or more cell-sites. Furthermore, path diversity may be obtained by exploiting the multipath environment through spread spectrum processing by allowing a signal arriving with different propagation delays to be received and processed separately. Examples of path diversity are illustrated in copending U.S. Patent No. 5,101,501 entitled "SOFT HANDOFF IN A CDMA CELLULAR TELEPHONE SYSTEM", and copending U.S. Patent No. 5,109,390, entitled "DIVERSITY RECEIVER IN A CDMA CELLULAR TELEPHONE SYSTEM", both assigned to the assignee of the present invention and incorporated by reference herein.

An additional technique that may be used to increase the efficiency of the allocation of the communication resource is to allow the users of the resource to provide data at varying rates thereby using only the minimum amount of the communication resource to meet their service needs. An example of a variable rate data source is a variable rate vocoder which is detailed in U.S. Patent Application Serial No. 08/004,484 which is a continuation application of U.S. Patent Application Serial No. 07/713,661, now abandoned, entitled "VARIABLE RATE VOCODER," assigned to the assignee of the present invention and incorporated herein by reference. Since speech inherently contains periods of silence, i.e. pauses, the amount of data required to represent these periods can be reduced. Variable rate vocoding most effectively exploits this fact by reducing the data rate for these periods of silence.

In a variable rate vocoder of the type described in aforementioned U.S. Patent Application Serial No. 08/004,484, approximately 40% of the speech packets are coded at full rate. In the vocoder described in the patent application, the encoding rate is selected in accordance with the packet energy. When the packet energy exceeds a full rate threshold the speech is coded at full rate. In US. Patent Application Serial No. 08/288,413, entitled "IMPROVED METHOD AND APPARATUS FOR SELECTING AN ENCODING RATE IN A VARIABLE RATE VOCODER," assigned to the assignee of the present invention and incorporated herein by reference, a

method for determining based on characteristics of the speech packet if some of the packets to be coded at full rate can be coded at a lower rate without sacrificing perceived quality.

A variable rate speech encoder provides speech data at full rate when the talker is actively speaking, thus using the full capacity of the transmission packets. When a variable rate speech coder is providing speech data at a less that maximum rate, there is excess capacity in the transmission packets. A method for transmitting additional data in transmission packets of a fixed predetermined size, wherein the source of the data for the data packets is providing the data at a variable rate is described in detail in copending U.S. Patent Application Serial No. 08/171,146, which is a continuation application of U.S. Patent Application Serial No. 07/822,164, now abandoned, entitled "METHOD AND APPARATUS FOR THE FORMATTING OF DATA FOR TRANSMISSION", assigned to the assignee of the present invention, of which the disclosure thereof is incorporated by reference herein. In the above mentioned patent application a method and apparatus is disclosed for combining data of differing types from different sources in a data packet for transmission.

SUMMARY OF THE INVENTION

A communications resource is typically divided into communications channels. Typically each of these channels has the same capacity. A communications system could re-allocate the channels to the users for each transmission. This would theoretically allow for a maximally efficient allocation of the communication resource because each user would be using only the amount of the resource absolutely necessary. However, this technique would result in unacceptable complexity in the resulting receiver and transmitter design.

In the present invention, an efficient method of transmitting and receiving variable rate data is disclosed. In the present invention, each user is provided with a voice or data channel, also referred to as a traffic channel, specifically allocated for that user. In addition, each user is provided with selective access to a pool of overflow channels which are for use by all users of the communications resource. If a user needs to transmit at a rate higher than the capacity of the allocated traffic channel then the user transmits the information using both the allocated traffic channel and an overflow channel.

In the exemplary embodiment, the communication system is a code division multiple access (CDMA) communication system as is described in detail in the aforementioned U.S. Patent Nos. 4,901,307 and 5,103,459. In the exemplary embodiment each of the traffic channels are orthogonal to one another. Each traffic channel is spread by a unique Walsh sequence that is orthogonal to the other Walsh sequences. The spread signals are then spread by pseudorandom noise (PN) sequences and then transmitted.

In the exemplary embodiment, the overflow channels are not provided with unique orthogonal Walsh spreading sequences, because this would decrease system capacity. Instead the system spreads the overflow channel portion of the information by a Walsh sequence that is not unique from those used in spreading the traffic channels. This portion is then spread by a PN sequence. The PN sequence is unique from the PN sequence used to spread the traffic channel of the same Walsh sequence. In the exemplary embodiment the traffic channel and the overflow channel use, although not necessarily, the same Walsh spreading sequence.

In the exemplary embodiment, the receiver continuously monitors both the traffic channel and the overflow channel. If the receiver determines that an information is being transmitted on both the traffic channel and an overflow channel then the receiver decodes both portions of the message, combines the portions and provides the decoded message to the user. In an alternative embodiment, the receiver need not continuously monitor the overflow channel, but rather only monitors the overflow channel when instructed by information on the traffic channel that directs the receiver to monitor the overflow channel.

BRIEF DESCRIPTION OF THE DRAWINGS

The features, objects, and advantages of the present invention will become more apparent from the detailed description set forth below when taken in conjunction with the drawings in which like reference characters identify correspondingly throughout and wherein:

Figure 1 is a diagram illustrating an exemplary implementation of the present invention in a satellite communication system;

Figures 2a-2d is an illustration of exemplary transmission packet structures of the exemplary embodiment;

Figures 3a-3e is an illustration of the symbol repetition in a transmission packet and the transmission energy level of the packet;

Figure 4 is a block diagram of the transmission system of the present invention; and

Figure 5 is a block diagram of a receiver system of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A multiple access communication resource is divided into parcels referred to as channels. This division is called multiplexing. Three specific types of multiplexing are frequency division multiplexing (FDM), time division multiplexing (TDM), and code division multiplexing (CDM). The basic unit of information transmitted and received in a communication system is referred to as a packet.

Referring now to the figures, Figure 1 illustrates the exemplary implementation of the present invention. In Figure 1, the present invention is implemented in a satellite communication network. It should be understood that the present invention may be utilized in a terrestrial based system such as one where base stations are used to communicate with remote stations. The network is used to communicate information to a remote user station or terminal 6 from gateway 8 via satellites 4 and 6 which may be either geosynchronous or low earth orbit (LEO) types. User terminal 2 may be a mobile station such as a portable telephone or other portable or mobile communications device or user terminal 2 may be a fixed communications device such as a wireless local loop terminal or a central communications center such as a cellular base station. Although only two satellite, a single user terminal, and a single gateway are shown in Figure 1 for ease in illustration, a typical system may contain a plurality of all.

In the exemplary embodiment, satellites 4 and 6 are transponders or non-regenerative repeaters that simply amplify and re-transmit the signal received from gateway 8. The present invention is equally applicable to cases where satellites 4 and 6 are regenerative repeaters that demodulate and reconstitute the signal prior to re-transmission. In the exemplary embodiment, the signal transmitted from gateway 8 to satellites 4 and 6 is a spread spectrum signal. In addition, the signals transmitted from satellites 4 and 6 to user terminal 2 are spread spectrum communications signals. The generation of spread spectrum communication signals is described in detail in the aforementioned U.S. Patent Nos. 4,901,307 and 5,103,459.

Gateway 8 serves as an interface from a communication network to the satellites 4 and 6, or directly to terrestrial base stations (a configuration not shown). Gateway 8 is typically a central communications center that receives data via a network (not shown) which may include public switching telephone networks (PSTN) and networks specifically designed for the communications of the present invention. Gateway 8 may be connected to the network (not shown) by wireline communications or by means of an air interface. Gateway 8 provides the data received from the network via satellites 6 and 8 to user terminal 2. Similarly gateway 8 provides data received from user terminal 12 via satellites 4 and 6 to the network.

In the exemplary embodiment, the communications network transmits variable rate data from gateway 8 to user terminal 2. A variable rate communication system communicates data where the rate of the data communicated varies with time. In the exemplary embodiment, the communications resource is divided into channels. In the exemplary embodiment, each channel has the same capacity.

In the exemplary embodiment gateway 8 communicates to user terminal 2 at one of four different information data rates. These data rates ordered from lowest rate to highest rate, are referred to, as eighth rate, quarter rate, half rate and full rate. In the exemplary embodiment, a single traffic channel has adequate capacity to carry the packet of all rates except full rate which requires a traffic and an overflow channel. In the exemplary embodiment, a traffic channel can carry packets of 96 bits or less. Half rate, quarter rate and eighth rate packets consist of 96, 48 and 24 bits respectively. A full rate packet consists of 192 bits and so requires a traffic channel plus an overflow channel of equal capacity.

The present invention is easily extendible to cases where there are more or less than four rates, where the channels can carry data at a lesser subset of the possible rates, or where the highest rate requires more than two channels. The communications system of the present invention can communicate both fixed rate data and variable rate data. In the communication of fixed rate data a channel or set of channels is to be allocated for the duration of the service being provided.

In the exemplary embodiment, the channels are designated into two groups. A first group of channels is the traffic channel group. Users are allocated traffic channels or sets of traffic channels specifically for their use for the duration of service. In the exemplary embodiment, all traffic channels are orthogonal to one another. In the exemplary embodiment this

orthogonality is attained by allocating a unique Walsh sequence to each user, as is described in detail in the aforementioned U.S. Patent Nos. 4,901,307 and 5,103,459. The information packets are spread, i.e. combined, with an orthogonal function sequence, typically a Walsh sequence, then the Walsh spread packet is mixed, i.e. spread spectrum processed with a pseudorandom noise (PN) sequence. Further details on the spread spectrum modulation of the information packets are provided in the aforementioned U.S. Patent Nos. 4,901,307 and 5,103,459.

Overflow channels are not provided with unique orthogonal or Walsh sequences and as such are not assured of being orthogonal to all traffic channels. However, the PN sequence which is mixed with the spread packet is unique, so all other packets will appear as noise to the decoder of the overflow channel and the overflow channel information can be distinguished from all traffic channel information.

Table 1 below illustrates the numerology used in the exemplary embodiment of the present invention.

Table 1. Exemplary numerology of the present invention.

Parameter					Units
Data Rate	8600	4000	1700	800	bps
PN Chip Rate	1.2288	1.2288	1.2288	1.2288	Mcps
Code Rate	1/2	1/2	1/2	1/2	bits/code symbol
Code Repetition	1	1	2	4	mod sym/code sym
# of Channels	2	1	1	1	
Modulation	BPSK	BPSK	BPSK	BPSK	

The present invention is equally applicable to other numerologies.

Figure 4 illustrates the transmission system of the present invention. Input data for transmission is provided to variable rate data source 50. Variable rate data source 50 provides the variable rate data to encoder 52. In the exemplary embodiment, variable rate data source 50 provides data at four different rates referred to as full rate, half rate, quarter rate and eighth rate. In the exemplary embodiment, full rate is 8.6 kbps and provides packets of 172 bits, half rate is 4 kbps and provides packets of 80 bits, quarter rate is 1.7 kbps and provides packets of 34 bits, and eighth rate is 800 bps and provides packets of 16 bits.

The exemplary embodiment of variable rate data source 50 is a variable rate vocoder as described in the aforementioned U.S Patent

Application Serial No. 08/004,484. In the exemplary variable rate vocoder, the energy of a packet of speech data is measured and compared to a set of threshold values which determine the encoding rate. The aforementioned U.S. Patent Application Serial No. 08/288,413 teaches of methods which minimize the number of packets encoded at full rate with minimum impact on perceptual quality.

Variable rate data source 50 encodes the input data and provides it at one of the predetermined rates. In the exemplary embodiment, a traffic channel is capable of carrying packets encoded at or below half rate. When a packet of data is encoded by variable rate data source 50 at full rate, then the packet must be transmitted using both a traffic channel and an overflow channel.

The data packet provided by variable rate data source 50 is provided to encoder 52. In the exemplary embodiment, encoder 52 generates a set of redundant bits in accordance with error correction and detection methods that are well known in the art. In the exemplary embodiment, the redundant bits are cyclic redundancy check (CRC) bits, the generation of which is well known in the art, and is detailed in the aforementioned copending U.S. Patent Application Serial No. 08/171,146.

Figures 2a-d illustrate the packet structures of the exemplary embodiment. Figure 2a illustrates the packet structure of a full rate packet consisting of 172 information bits followed by 12 redundant bits and then by 8 tail bits. Figure 2b illustrates the packet structure of a half rate packet consisting of 80 information bits followed by 8 redundant bits and then by 8 tail bits. Figure 2c illustrates the packet structure of a quarter rate packet consisting of 34 information bits followed by 6 redundant bits and then by 8 tail bits. Figure 2d illustrates the packet structure of a eighth rate packet consisting of 16 information bits followed by 8 tail bits.

Referring back to Figure 4, encoder 52 then encodes the formatted packet for error detection and correction as is well known in the art. In the exemplary embodiment, encoder 52 encodes the formatted packet in accordance with a rate 1/2 convolutional code. Encoder 52 provides the encoded packet to interleaver 54.

Interleaver 54 interleaves the binary symbols of the encoded packet in accordance with a predetermined interleaver format. In the exemplary embodiment, interleaver 54 is a block interleaver. In addition, interleaver 54 provides redundancy in the packets such that each interleaved packet consists of the same number of binary symbols as described below.

Referring to Figures 3a-3e in conjunction with Figure 4, interleaver 54 interleaves the binary symbols of the packet, then groups the reordered binary symbols into power control groups. Figure 3a and 3b illustrate a full rate packet organized into a packet format. Because a full rate packet of a transmission packet requires two channels, the first portion of the packet illustrated in Fig. 3a is organized into a traffic packet and transmitted on the traffic channel. The second portion of the full rate packet as illustrated in Fig. 3b is organized into an overflow packet and transmitted on an overflow channel. For the full rate packet interleaver 54 does not provide symbol repetition. Since the symbol data fills the traffic channel and the overflow channel packet. In the exemplary embodiment, each power control group consists of 12 binary symbols. Fig. 3c illustrates a half rate packet organized into a packet format. Note that because transmission of the half rate packet utilizes the full capacity of the traffic channel packet, there is no symbol repetition provided in the packet. Fig 3d illustrates a quarter rate packet organized into a packet format, in which each symbol is provided twice. Fig 3e illustrates an eighth rate packet organized into packet format, in which each symbol is provided four times.

Referring again to figure 4, the interleaved packet is provided by interleaver 54 to de-multiplexer 56, which operates in accordance with a rate signal provided by variable rate data source 50. If the packet is such that it can be carried on the traffic channel without need of an overflow channel then the interleaved packet is provided through de-multiplexer (DE-MUX) 56 without any change to modulator 57. If, on the other hand, the packet requires use of an overflow channel for transmission, then de-multiplexer 56 splits the packet into two portions. The de-multiplexed packet is provided by de-multiplexer 56 to modulator 57. Buffering may be added to insure two portions are simultaneously provided to modulator 57.

In the exemplary embodiment if the packet is of a rate less than full rate, then the entire packet is provided to combining element 58, which in the exemplary embodiment is a digital multiplier modulo 2 adder or exclusive or gate. The interleaved packet is spread by an orthogonal function W_i, as is described in detail in the aforementioned U.S. Patent No. 5,103,459. In the exemplary embodiment, orthogonal function W_i is a Walsh function the selection of which is detailed in the aforementioned U.S. Patent No. 5,103,459. In the exemplary embodiment, each Walsh sequence, W_i, is uniquely provided for use by User (i).

The orthogonal function spread packet from element 58 is provided to quadrature spreading elements 62 and 64 which are employed as digital

multipliers modulo 2 adder or exclusive or gates The orthogonal function spread packet is spread in quadrature spreading elements 62 and 64 by pseudorandom noise (PN) functions PN_I and PN_Q, respectively. PN_I and PN_Q are generated by traffic PN generator 63. In the exemplary embodiment, the pseudorandom noise signals are generated by a maximal shift register where the PN sequence is determined by the temporal offset of the register. The design and implementation of such registers is described in detail in the aforementioned copending U.S. Patent No. 5,228,054. The quadrature spread packets are provided from quadrature spreading elements 62 and 64 to transmitter 72.

Transmitter 72 converts the signal to analog form, frequency upconverts and amplifies the signal for transmission transmitter 72 amplifies the signal in accordance with the rate of the packet. The relationship between the necessary transmission energy and the amount of repetition is illustrated in Figures 3a-3e. When a redundancy is present in a packet, the packet can be transmitted at a lower energy with redundant portions combined at the receiver. In a full rate packet both the packet on the traffic channel (traffic packet) Fig. 3a and the packet transmitted on the overflow channel (overflow packet) Fig. 3b are transmitted at a maximum bit energy E. In Figure 3c, there is no repetition in the half rate packet so the packet is also provided at energy level E. In Figure 3d, there is a repetition rate of two so the packet is provided at half the packet energy of the half rate packet or E/2. In Figure 3e, there is a repetition rate of four so the packet is provided at a quarter of the packet energy of the half rate packet or E/4. Transmitter 72 amplifies and upconverts the signal and provides it to antenna 74 for broadcast to a receiver.

In the case where a packet requires use of an overflow channel for transmission that is the packet is a full rate packet, then de-multiplexer 56 splits the interleaved packet into two halves and provides a first half to combining element 58 and a second half of the packet to combining element 60 which is also embodied as a digital multiplier, modulo 2 adder or an exclusive-or gate. The modulation of the first half of the packet proceeds as described previously for packets of less than full rate. The modulation of the second half of the packet is the same except that the spreading functions are different.

Now turning to the specifics of the modulation process of modulator 57, it should be noted that a spread spectrum communication system is primarily limited in capacity by the number of unique orthogonal functions or in the exemplary embodiment Walsh functions available. If one allocates

a subset of these functions for the purpose of modulating the overflow channels, then the capacity of the system is reduced.

In the present invention, all of the traffic channels are orthogonal to one another, because each is modulated by a unique Walsh function (W_i) or Walsh code sequence. However, the Walsh functions provided for modulation of the overflow channel (W_j) will overlap those allocated for modulation of the traffic channel and so are not orthogonal to the traffic channels. In the exemplary embodiment, W_i is the same Walsh function as W_j. That is the same Walsh code function spreads the traffic channel portion of the packet as it spreads the overflow portion of the packet. The two signals are distinguished from one another by subsequent PN code sequence spreading.

The spread packet from combining element 60 is provided to quadrature spreading elements 66 and 68 which may be embodied as digital multipliers, modulo 2 adders, or exclusive-or gates. Quadrature spreading elements 66 and 68 spread the packet from spreading element 60 in accordance with pseudorandom noise functions PN_I' and PN_Q'. Pseudorandom noise functions PN_I' and PN_Q' are generated by overflow PN generator 67. In the exemplary embodiment, pseudorandom noise functions PN_I' and PN_Q' are generated in the same manner as pseudorandom noise functions PN_I and PN_Q, but are unique due to different temporal offsets in the code sequences.

In a first exemplary embodiment, pseudorandom noise functions PN_I and PN_Q and pseudorandom noise functions PN_I' and PN_Q' are short codes. A short code is a code in which the number of sequences generated is relatively few. In the exemplary embodiment, the PN generator provides a bit stream that is periodic with a period of 2^{15} PN chips. The benefit of this implementation is that it allows a faster acquisition at the receiver. In an alternative embodiment, pseudorandom noise functions PN_I and PN_Q are short codes, but pseudorandom noise functions PN_I' and PN_Q' are long codes. This has the potential of advantage of greater separation in code space, while allowing the mobile to acquire using the demodulation of the first sub-packet modulated by the short code.

The modulated overflow packet from quadrature spreading elements 66 and 68, as well as the modulated traffic packet from quadrature spreading elements 62 and 64 are provide to transmitter 72. Transmitter upconverts and amplifies the signal and provides the signal to antenna 74 for broadcast.

The sub-packets are transmitted with energy E as illustrated in Figures 3a and 3b (vertical axis).

Figure 5 illustrates the receiver system of the present invention. The transmitted signal is received at antenna 100 and provided to receiver 102. Receiver 102 down converts and amplifies the signal and provides the signal in its two components I and Q to overflow channel despreading element (OVERFLOW DESPREADER) 104 and to traffic channel despreading element (TRAFFIC DESPREADER) 120. In the exemplary embodiment the I component and the Q component of the received signal carry the same data, which allows for a higher quality reception. In an alternative embodiment, the I and Q components could carry different data which would allow for higher data rate. In the exemplary embodiments despreaders 104 and 120 are configured as QPSK despreading circuits as are well known in the art.

The received signal is provided to traffic channel despreading element (TRAFFIC DESPREADER) 120, which de-spreads the signal in accordance with the traffic channel pseudorandom noise codes PN_I and PN_Q. Traffic PN generator 119 generates the PN_I and PN_Q sequences. In the exemplary embodiment the PN sequences are generated by a shift register with appropriate feedback. The de-spreading process involves digitally multiplying the signal by the traffic channel pseudorandom noise codes PN_I and PN_Q. This process is described in detail in the aforementioned U.S. Patent Nos. 4,901,307 and 5,103,459. Similarly, the received signal is provided to overflow channel despreading element (OVERFLOW DESPREADER) 104, which de-spreads the signal in accordance with the overflow channel pseudorandom noise codes PN_I' and PN_Q'. Overflow PN generator 119 generates the PN_I' and PN_Q' sequences. In the exemplary embodiment the PN sequences are generated by a shift register with appropriate feedback. In the exemplary embodiment, the two generators are identical except that they are offset from one another temporally, which means that the traffic PN sequences and the overflow PN sequences will be unique from one another.

The despread signal is then provided to demodulation elements 105 and 121. Demodulation element 121 receives the traffic channel despread I and Q values and demodulates the signal. The demodulation process is illustrated by the digital multiplication of the signal by the Walsh function W_i in multipliers 122 and 124 then the accumulation of the multiplied signal in accumulators 126 and 128. Similarly, the demodulation of the overflow channel is illustrated by the digital multiplication by the Walsh

function W_j in multipliers 106 and 110 then the accumulation of the multiplied signal in accumulators 108 and 112.

The demodulated signal is provided by traffic demodulator 121 to combiner element 130 and by overflow demodulator 105 to combiner element 114. The combiner elements combine received and despread data estimates from despreaders 105 and 121 with data estimates from other receiver/despreader/demodulators demodulated fingers (not shown) that are simultaneously being tracked by the receiver system. These other estimates take advantage of the delayed signals resulting from multipath signals to provide an improved signal estimate. The design and implementation of combiner elements are described in detail in the aforementioned U.S. Patent Nos. 5,101,501 and 5,109,390.

The combiners combine the signals based upon the values of the data and the relative strengths of the signals and provide combined estimates to de-interleaving element (DE-INT) 116. De-interleaving element 116 re-orders the combined estimates of the data in accordance with a predetermined ordering format and provides the reordered data to decoder (DECODE) 118. Decoder 118 decodes the data in accordance with a predetermined decoding format. In the exemplary embodiment, decoder 118 is a Viterbi decoder of constraint length 7. The decoded packet is then provided to the receiver system user.

In an improved embodiment of the communication system of the present invention, an alternative modulation and demodulation process is provided for when system usage is low. When system usage is low, each user is provided use of one of the unique Walsh sequences for communication of its overflow data. That is, W_i and W_j are different so the traffic and overflow signals are orthogonal to one another. In the exemplary embodiment, W_i and W_j are separated by a fixed offset from one another so that the receiver knows which Walsh sequence to use to demodulate the overflow signal. In the exemplary embodiment of a communication system of 128 unique Walsh sequences, when usage is low, each user is allocated a traffic channel designated by Walsh sequence W_i and uses an overflow channel designated by Walsh sequence $W_j = W_i + 64$.

When system usage rises so that the system can no longer accommodate this many unique overflow channels, that is 65 or more users, then the system transmitter will send signaling information to the receiver indicating that the overflow communications will be conducted as described previously, using the same Walsh sequence for both traffic and overflow

communications. The users may be switched to the high usage mode individually as necessary or as a group.

The previous description of the preferred embodiments is provided to enable any person skilled in the art to make or use the present invention. The various modifications to these embodiments will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments without the use of the inventive faculty. Thus, the present invention is not intended to be limited to the embodiments shown herein but is to be accorded the widest scope consistent with the principles and novel features disclosed herein.

WE CLAIM:

CLAIMS

1. An apparatus for transmitting a variable rate packet of data symbols comprising:

channel packetizer means for receiving said variable rate packet and when the number of said data symbols exceeds a threshold value, splitting said variable rate packet into a traffic packet and at least one overflow packet; and

transmission means for transmitting said variable rate packet on a traffic channel when number of said data symbols is below said threshold value and for transmitting said traffic packet on said traffic channel and said at least one overflow packet on at least one overflow channel when the number of said data symbols exceeds said threshold value.

2. The apparatus of Claim 1 wherein said transmitter means comprises:

modulator means for modulating said variable rate packet to provide said variable rate packet on said traffic channel in a accordance with a first spread spectrum modulation format when the number of said data symbols is below said threshold value and for modulating said traffic packet to provide said traffic packet on said traffic channel in a accordance with said first spread spectrum modulation format and for modulating said at least one overflow packet to provide said at least one overflow packet on said at least one overflow channel when the number of said data symbols exceeds said threshold value; and

transmitter means for upconverting and amplifying said variable rate packet when the number of said data symbols is below said threshold value and for upconverting and amplifying said traffic packet and said at least one overflow packet when the number of said data symbols exceeds said threshold value.

3. The apparatus of Claim 2 wherein said modulator means is for modulating said traffic packet in accordance with a traffic pseudorandom noise sequence and for modulating said overflow packet in accordance with a overflow pseudorandom noise sequence.

4. The apparatus of Claim 3 wherein said modulator means is further for spreading said traffic packet and said overflow packet in accordance with a spreading function.

5. The apparatus of Claim 1 wherein said channel packetizer means is responsive to a rate signal.

6. The apparatus of Claim 1 further comprising variable rate vocoder means for receiving speech samples and for compressing said speech samples in accordance with a variable rate vocoder format to provide said variable rate packet.

7. The apparatus of Claim 6 further comprising encoder means disposed between said variable rate vocoder means and for error correction coding said variable rate packet.

8. The apparatus of Claim 7 further comprising interleaver means disposed between said encoder means and said variable rate vocoder means for reordering said variable rate packet.

9. The apparatus of Claim 2 wherein said modulator means is for modulating said traffic packet in accordance with a first quadrature traffic pseudorandom noise sequence and in accordance with a first quadrature traffic pseudorandom noise sequence and for modulating said overflow packet in accordance with a first quadrature overflow pseudorandom noise sequence and in accordance with a second quadrature overflow pseudorandom noise sequence.

10. A method for transmitting a variable rate packet of data symbols comprising the steps of:

receiving said variable rate packet;

splitting said variable rate packet into a traffic packet and at least one overflow packet when the number of said data symbols exceeds a threshold value;

transmitting said variable rate packet on a traffic channel when number of said data symbols is below said threshold value;

transmitting said traffic packet on said traffic channel when the number of said data symbols exceeds said threshold value; and

transmitting said at least one overflow packet on at least one overflow channel when the number of said data symbols exceeds said threshold value.

11. The method of Claim 10 further comprising the steps of:

modulating said variable rate packet to provide said variable rate packet on said traffic channel in a accordance with a first spread spectrum modulation format when the number of said data symbols is below said threshold value;

modulating said traffic packet to provide said traffic packet on said traffic channel in a accordance with said first spread spectrum modulation format when the number of said data symbols exceeds said threshold value;

modulating said at least one overflow packet to provide said at least one overflow packet on said at least one overflow channel in a accordance with said second spread spectrum modulation format when the number of said data symbols exceeds said threshold value.

12. The method of Claim 11 wherein said step of modulating said traffic packet comprises modulating said traffic packet in accordance with a traffic pseudorandom noise sequence and wherein said step of modulating said at least one overflow packet comprises modulating said overflow packet in accordance with a overflow pseudorandom noise sequence.

13. The method of Claim 12 wherein said steps of modulating said traffic packet and modulating said at least one overflow packet further comprises spreading said traffic packet and said overflow packet in accordance with a spreading function.

14. The method of Claim 10 further comprising the steps of:

receiving speech samples; and

compressing said speech samples in accordance with a variable rate vocoder format to provide said variable rate packet.

15. The method of Claim 14 further comprising the step of error correction coding said variable rate packet.

16. The method of Claim 7 further comprising the step of interleaving said variable rate packet.

17. A system for transmitting a variable rate packet of data symbols comprising:

a channel packetizer having an input for receiving said variable rate packet and having an output; and

a transmitter having an input coupled to said channel packetizer output and having an output.

18. The system of Claim 17 further comprising a spread spectrum modulator interposed between said channel packetizer and said transmitter having an input coupled to said channel packetizer output and having an output coupled to said transmitter input.

19. The apparatus of Claim 18 wherein said modulator comprises:

a traffic spreader having a first input for receiving an orthogonal spreading sequence and having a second input for receiving said variable rate packet and having an output;

a first quadrature traffic spreader having a first input coupled to said traffic spreader output and having a second input for receiving a first pseudorandom noise (PN) traffic sequence and having an output;

a second quadrature traffic spreader having a first input coupled to said traffic spreader output and having a second input for receiving a second pseudorandom noise (PN) traffic sequence and having an output;

an overflow spreader having a first input for receiving an orthogonal spreading sequence and having a second input for receiving said variable rate packet and having an output;

a first quadrature overflow spreader having a first input coupled to said overflow spreader output and having a second input for receiving a first pseudorandom noise (PN) overflow sequence and having an output; and

a second quadrature overflow spreader having a first input coupled to said overflow spreader output and having a second input for receiving a second pseudorandom noise (PN) overflow sequence and having an output.

20. An apparatus for receiving a variable rate packet of data symbols comprising:

traffic demodulator means for demodulating a received traffic packet in accordance with a traffic demodulation format to provide a demodulated traffic packet;

overflow demodulator means for demodulating a received overflow packet in accordance with a overflow demodulation format to provide a demodulated overflow packet; and

combiner means for combining said demodulated traffic packet and said demodulated overflow packet to provide said variable rate packet.

21. The apparatus of Claim 20 wherein said traffic demodulator means comprises:

traffic pseudorandom noise (PN) generator means for generating a traffic PN sequence; and

traffic despreader means for receiving said traffic packet and despreading said traffic packet in accordance with said traffic PN sequence to provide a demodulated traffic packet;

and wherein said overflow demodulator means comprises:

overflow pseudorandom noise (PN) generator means for generating an overflow PN sequence; and

overflow despreader means for receiving said overflow packet and despreading said overflow packet in accordance with said overflow PN sequence to provide a demodulated overflow packet.

22. The apparatus of Claim 21 wherein said traffic demodulator means further comprises:

orthogonal traffic sequence generator means for generating an orthogonal traffic sequence;

orthogonal traffic despreader means for receiving said demodulated traffic packet and despreading said demodulated traffic packet in accordance with said orthogonal traffic sequence;

orthogonal overflow sequence generator means for generating an orthogonal overflow sequence; and

orthogonal overflow despreader means for receiving said demodulated overflow packet and despreading said demodulated overflow packet in accordance with said orthogonal overflow sequence;

23. A method for receiving a variable rate packet of data symbols comprising the steps of:

demodulating a received traffic packet in accordance with a traffic demodulation format to provide a demodulated traffic packet;

demodulating a received overflow packet in accordance with a overflow demodulation format to provide a demodulated overflow packet; and

combining said demodulated traffic packet and said demodulated overflow packet to provide said variable rate packet.

24. The method of Claim 23 wherein said step of demodulating said received traffic packet comprises the steps of:

generating a traffic PN sequence; and

despreading said traffic packet in accordance with said traffic PN sequence to provide a demodulated traffic packet;

and wherein said step of demodulating said received overflow packet comprises the steps of:

generating a overflow PN sequence; and

despreading said overflow packet in accordance with said overflow PN sequence to provide a demodulated overflow packet.

25. The apparatus of Claim 24 wherein said step of demodulating said received traffic packet further comprises the steps of:

generating an orthogonal traffic sequence;

despreading said demodulated traffic packet in accordance with said orthogonal traffic sequence;

generating an orthogonal overflow sequence; and

despreading said demodulated overflow packet in accordance with said orthogonal overflow sequence;

26. A system for receiving a variable rate packet of data symbols comprising:

a traffic demodulator having an input and having an output;

an overflow demodulator having an input and having an output; and

a combiner having a first input coupled to said traffic demodulator output and having a second input coupled to said overflow demodulator output and having an output.

27. The system of Claim 26 wherein said traffic demodulator comprises:

a traffic pseudorandom noise (PN) generator having an output; and

a traffic despreader having a first input coupled to said traffic pseudorandom noise (PN) generator output;

and wherein said overflow demodulator comprises:

a overflow pseudorandom noise (PN) generator having an output; and

a overflow despreader having a first input coupled to said overflow pseudorandom noise (PN) generator output.

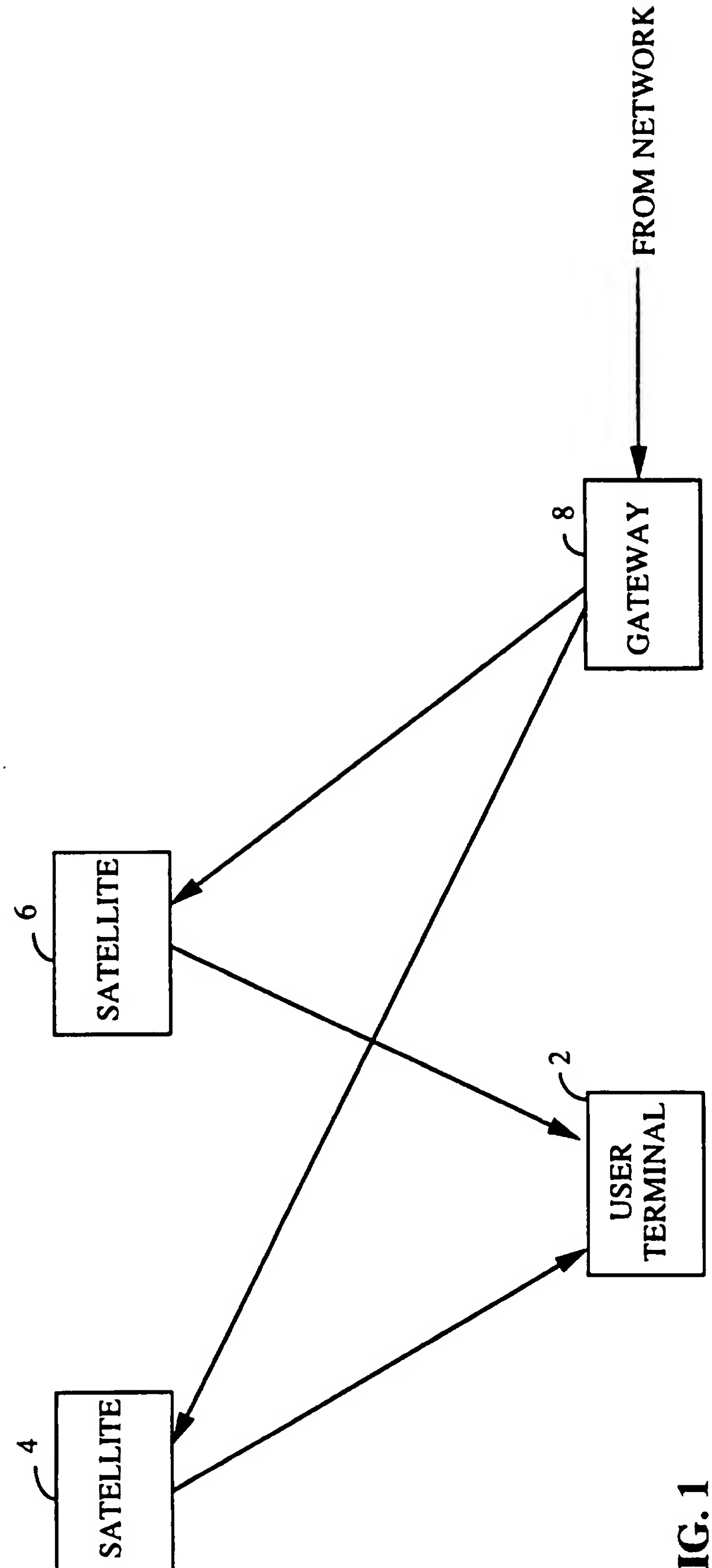

FROM NETWORK
GATEWAY
8
SATELLITE
6
USER TERMINAL
2
SATELLITE
4

FIG. 1

FIG. 2a

9.6 KBPS PACKET FORMAT

FIG. 2b

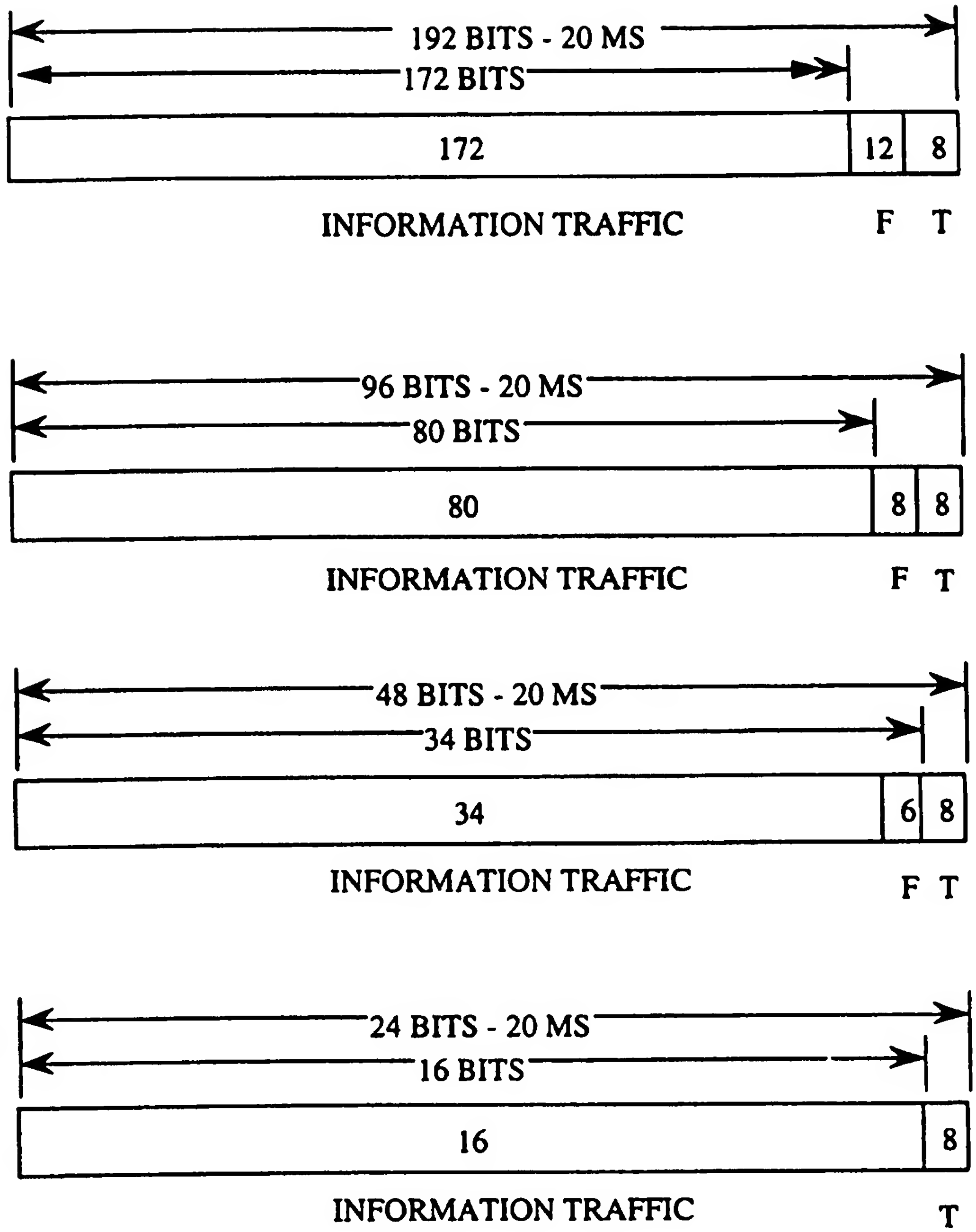
4.8 KBPS PACKET FORMAT

FIG. 2c

2.4 KBPS PACKET FORMAT

FIG. 2d

1.2 KBPS PACKET FORMAT



F - REDUNDANT BINARY SYMBOLS
T - TAIL BINARY SYMBOLS

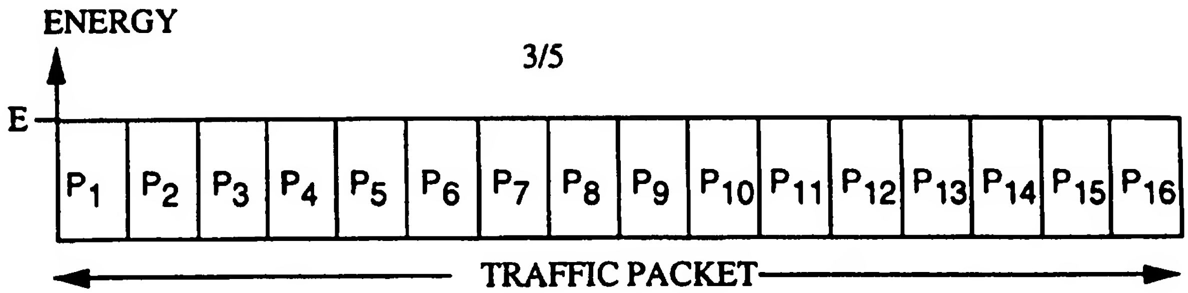


FIG. 3a

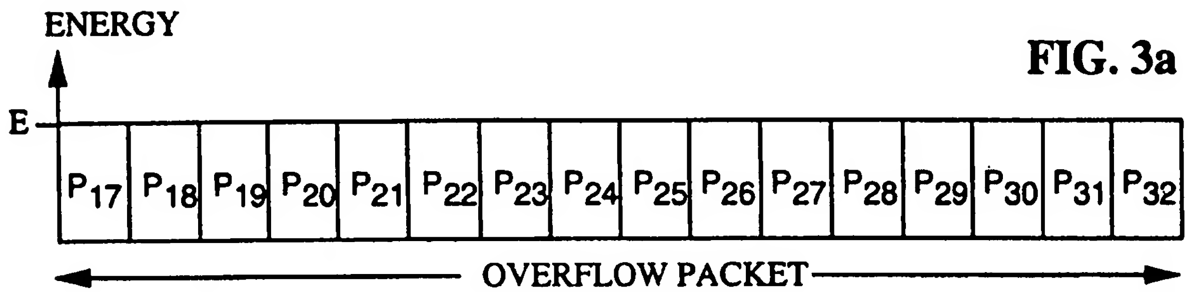


FIG. 3b

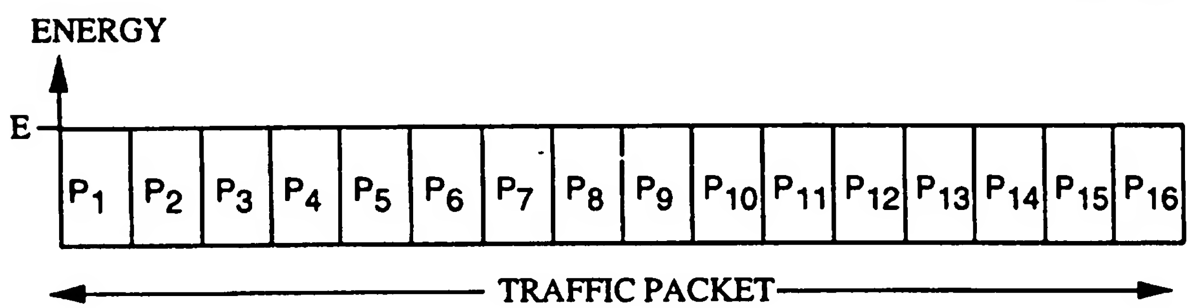


FIG. 3c

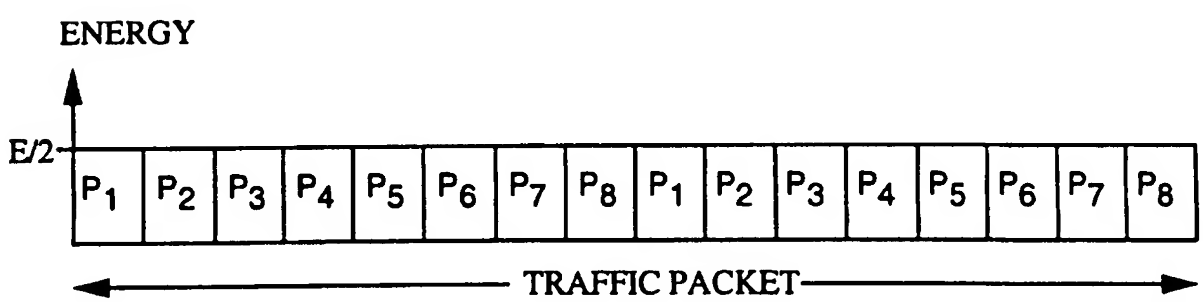


FIG. 3d

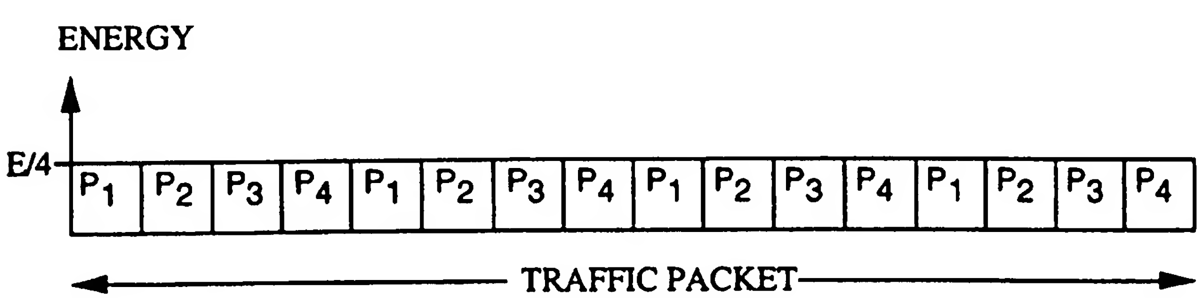


FIG. 3e

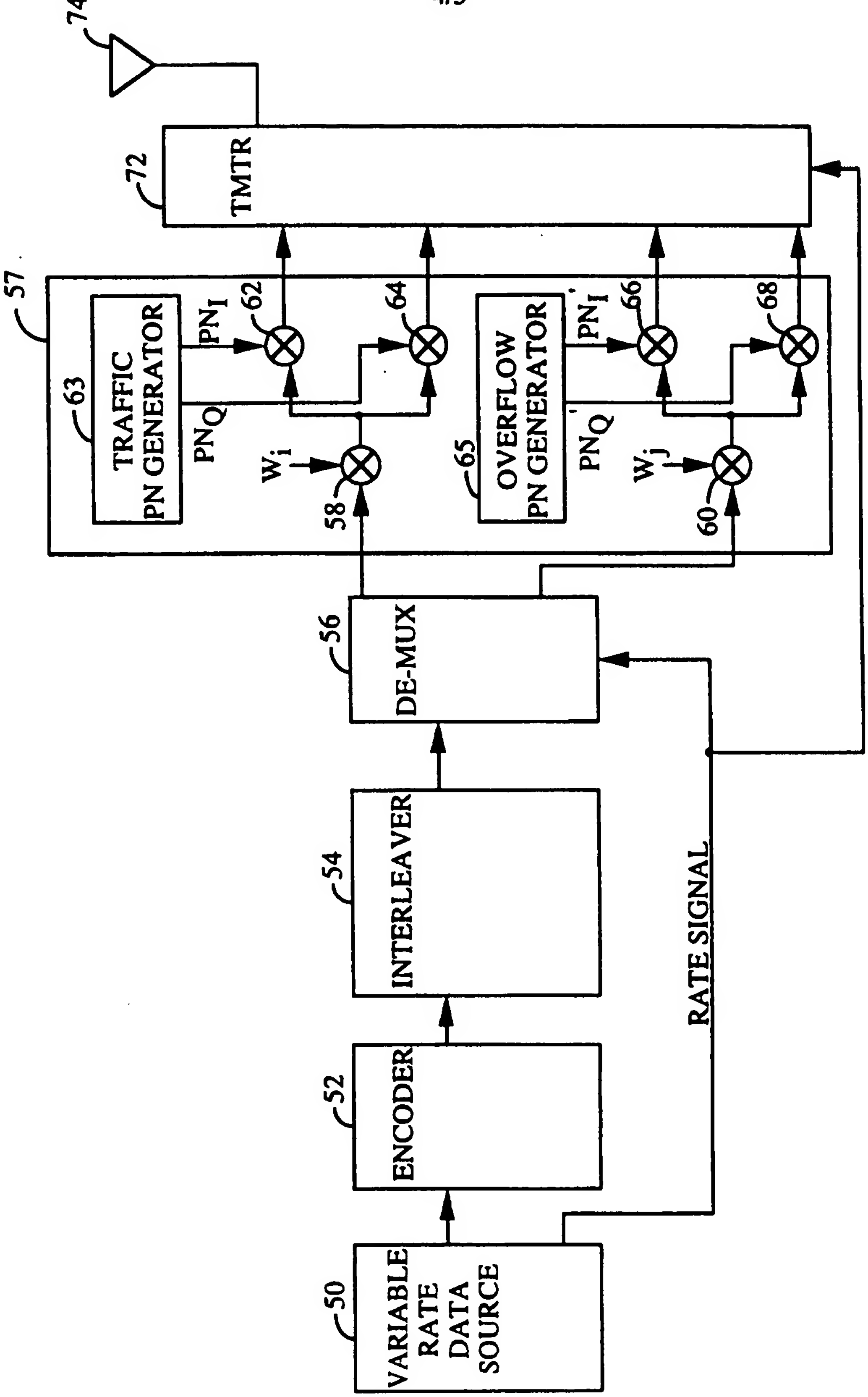

74
TMTR
72
57
TRAFFIC PN GENERATOR
63
PN_I
PN_Q
62
64
W_i
58
OVERFLOW PN GENERATOR
65
PN_I'
PN_Q'
66
68
W_j
60
DE-MUX
56
INTERLEAVER
54
ENCODER
52
VARIABLE RATE DATA SOURCE
50
RATE SIGNAL

FIG. 4

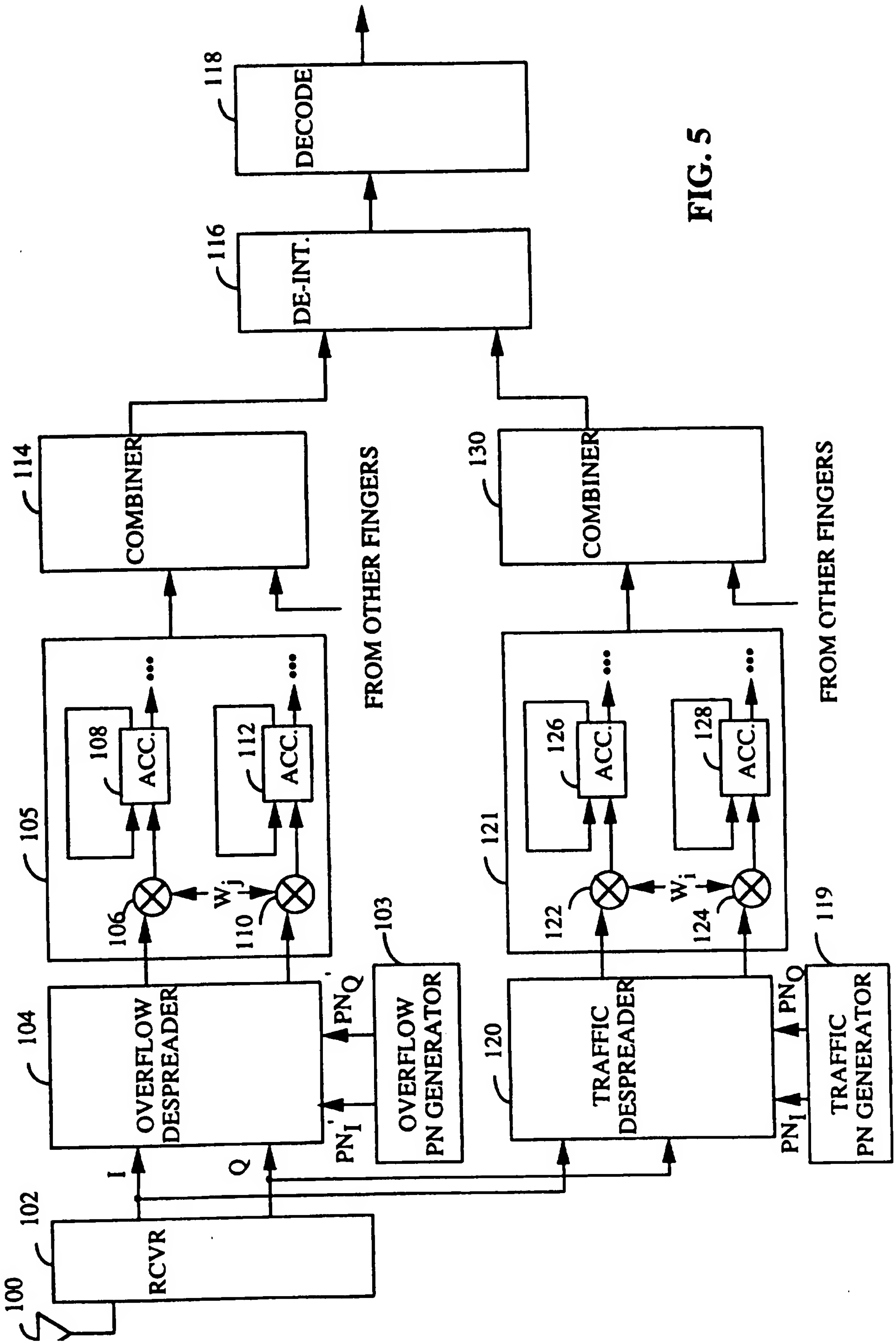

100
102
RCVR
I
Q
104
OVERFLOW
DESPREADER
PN_I'
PN_Q'
103
OVERFLOW
PN GENERATOR
105
106
110
W_j
108
ACC.
112
ACC.
114
COMBINER
FROM OTHER FINGERS
116
DE-INT.
118
DECODE
120
TRAFFIC
DESPREADER
PN_I
PN_Q
119
TRAFFIC
PN GENERATOR
121
122
124
W_i
126
ACC.
128
ACC.
130
COMBINER
FROM OTHER FINGERS

FIG. 5

INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/US 96/02607

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04J11/00 H04J13/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04J H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US,A,5 373 502 (TURBAN KARL-ALBERT) 13 December 1994	1-6, 10-14, 17,18, 20,21, 23,24, 26,27
	see column 1, line 26 - line 33 see column 2, line 63 - line 68 see column 4, line 5 - line 22	
Y	see column 4, line 31 - column 5, line 10	7-9,15, 16,19, 22,25
	see column 6, line 29 - line 56 see column 7, line 19 - line 45 see column 8, line 28 - line 39 see figures 1-3 --- -/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

1

Date of the actual completion of the international search	Date of mailing of the international search report
25 June 1996	24. 07. 96

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Pieper, T

INTERNATIONAL SEARCH REPORT

Inv ional Application No
PCT/US 96/02607

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US,A,5 103 459 (GILHOUSEN KLEIN S ET AL) 7 April 1992 cited in the application see column 6, line 56 - line 60 see column 10, line 4 - line 14 see column 22, line 5 - line 24 see column 24, line 39 - line 53 see column 33, line 18 - line 24 see figures 1,11,12 -----	7-9,15, 16,19, 22,25

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 96/02607

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		CA-A-	2092874	01-10-93
		EP-A-	0567771	03-11-93
US-A-5103459	07-04-92	AU-B-	652956	15-09-94
		AU-B-	8401691	23-01-92
		BG-A-	97222	27-05-94
		CA-A-	2085890	26-12-91
		CN-A-	1061312	20-05-92
		EP-A-	0536334	14-04-93
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		US-A-	5504773	02-04-96
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